

# PATENT SPECIFICATION

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## (54) METHOD OF PRODUCING COMPOSITE BOARD STRUCTURE INCLUDING CORRUGATED FIBERBOARD

(71) We, NISSAN MOTOR COMPANY, LIMITED, a corporation organized under the laws of Japan, of No. 2, Takaramachi, Kanagawa-ku, Yokohama City, Japan, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to a method producing a composite board structure and, more particularly, to a composite board structure including a corrugated fiberboard as a basic component.

A composite board structure of the character to which the present invention appertains generally comprises a corrugated fiberboard and a facing web of a non-woven fabric or a thermoplastic material such as a cellular foam of polyurethane. The corrugated fiberboard used as the basic component of the composite board structure includes at least one planar liner and at least one corrugated medium of a paperboard or a thermoplastic material which is bonded at the tops of its ridge portions to one face of the liner. The facing web of the non-woven fabric or thermoplastic material is bonded over its total area to the corrugated fiberboard by means of a layer of a hot melt adhesive material of, usually, a thermoplastic synthetic resin polymer.

Composite board structures having such a basic construction are not only useful as ordinary packaging materials to form cartons, boxes and other types of containers but find a wide variety of practical applications where insulation of heat and/or sound and/or dampening out of mechanical vibrations is a serious requirement. The composite board structures have therefore proved useful particularly as interior linings for walls, floors and ceiling panels of residential or office buildings or as facings, trims and interlayers for various structural members of automotive vehicles, ships or boats, and aircrafts, for their stiffness, excellent heat and sound absorbing performances lightweight constructions, low production and insulation costs, and ease of processing corrugated fiberboards in such a

manner that the fiberboards are inelastically deformed into three-dimensionally curved configurations without producing creases and fissures in the corrugated fiberboards.

When in bonding a facing web of a non-woven fabric or a thermoplastic material to a corrugated fiberboard during production of a composite board structure, the corrugated fiberboard and the facing web are heated to certain temperatures while the facing web is being pressed onto the corrugated fiberboard with a thin film of a hot melt adhesive material interposed between the corrugated fiberboard and the facing web. By the heat thus applied to the facing web and the corrugated fiberboard, the film of the hot melt adhesive material therebetween is fused throughout the area of the film and causes the facing web to stick to the corrugated fiberboard. When the corrugated fiberboard and the facing web are then allowed or forced to cool thereafter, the film of the fused hot melt adhesive material is set and forms a layer uniting the facing web and the corrugated fiberboard together.

Where the corrugated medium forming part of a corrugated fiberboard is made of paper, the corrugated paper medium is bonded at the tops of its ridge portions to the liner or liners of the fiberboard usually by the use of a hot melt adhesive material which is initially in the form of a thin film interposed between the corrugated paper medium and the liner or each of the liners. When such a corrugated fiberboard is heated while being deformed into a desired configuration with a facing web attached to one face of the corrugated fiberboard, not only the hot melt adhesive material between the facing web and the corrugated fiberboard but the hot melt adhesive material between the corrugated paper medium and the liner or each of the liners is fused transferred thereto and causes the liner or liners to stick to the corrugated paper medium simultaneously when the facing web is caused to stick to the corrugated fiberboard. The hot melt adhesive material thus fused between the corrugated paper medium and the liner or each of the liners is set and securely unite

the corrugated paper medium and the liner or liners together when the corrugated fiberboard is thereafter allowed to cool. The layer of the hot melt adhesive material between the corrugated medium and the liner or liners of the corrugated fiberboard forming part of the composite board structure thus prepared is effective not only to hold the corrugated paper medium bonded at the tops of its ridge portions to the liner or liners of the corrugated fiberboard but to inelastically maintain the configuration of the corrugated fiberboard which has been deformed from an initially flat blank.

The corrugated medium of a corrugated fiberboard to be used as the basic component of a composite board structure of the character at which the present invention is directed may be made of a thermoplastic material which is fusible when heated. When the corrugated fiberboard of such a nature is heated during production of a composite fiberboard having a facing web attached to the corrugated fiberboard, the corrugated medium per se is fused at the tops of its ridge portions held in contact with the liner or liners of the corrugated fiberboard and is fusion bonded to the liner or liners without aid of any extra adhesive material. The corrugated medium is thus securely fastened directly to the liner or liners when the corrugated fiberboard is allowed to cool and accordingly the corrugated medium which has been locally fused is set.

Whichever type of corrugated fiberboard may be put use as the basic component of a composite board structure, the corrugated fiberboard must be heated to a high temperature so that either the film of the hot melt adhesive material on the corrugated paper medium is properly fused on the liner or each of the liners or the corrugated medium of a thermoplastic material is properly fused at the tops of its ridge portions in contact with the liner or each of the liners. If, in this instance, the corrugated fiberboard is heated to an excessively high temperature, the facing web in contact with the corrugated fiberboard would be also heated excessively and might be caused to impair its original external appearance depending upon the material forming the facing web. If, for example, the facing web is formed of a thermoplastic material and has embossed patterns on its outer face and if such a facing web is heated to an excessively elevated temperature, the embossed patterns of the facing web would be caused to be flattened out and as a consequence the initial clear-cut boundaries of the patterns would be spoiled when the facing web is pressed onto the corrugated fiberboard by a pressing surface in pressing contact with the embossed outer face of the web. If, on the other hand, the facing web is formed of a non-woven fabric, then the naps or piles of

such a fabric would be caused to fall and as a consequence the initial soft, fluffy texture and external appearance of the web would be critically damaged or lost when the facing web is heated to an excessively high temperature. If, conversely, the corrugated fiberboard fails to be heated to a sufficiently high temperature, then the heat applied to the liner or each of the liners would be unable to take up the mechanical stresses and strains which tend to be produced in the liner and would cause the liner or liners to produce creases and fissures therein especially when the liner or liners on the corrugated paper medium are being deformed three-dimensionally. This would also critically impair the commercial value of the resultant composite board structure.

It is, for these reasons, of paramount importance to precisely control the temperatures to which the facing web and the corrugated fiberboard are to be heated during production of a composite board structure using a corrugated fiberboard as the basic component of the structure.

Excessive heating of a facing web on a corrugated fiberboard could be avoided if a sheet of insulating material is additionally interposed between the facing web and the corrugated fiberboard so as to reduce the amount of heat to be transferred from the corrugated fiberboard to the facing web. Provision of such an extra material in a composite board structure will not only raise the production cost of the composite board but will make the board structure disproportionately bulky in construction and heavy in weight and would also impair the commercial value of the article.

The present invention contemplates elimination of these drawbacks which have thus far been inherent in the production of composite board structures using corrugated fiberboards as the basic components.

It is, accordingly, an object of the present invention to provide a method of producing a composite board structure which is deformed into a desired configuration from an initially flat fiberboard and securely attached to a facing web of a non-woven fabric or a thermoplastic material in such a manner that both the facing web and the corrugated fiberboard are heated to proper temperatures that will allow the facing web to maintain its original external appearance and enable the corrugated fiberboard to take up the stresses and strains which tend to be produced when the corrugated fiberboard is being produced.

In accordance with the present invention, such an object is accomplished basically in a method of producing a composite board structure, comprising preparing a corrugated fiberboard by joining a liner to a corrugated medium such that the tops of the ridge portions defined on one side of said corrugated

medium are bonded to the inner face of said liner by means of a thermoplastic material which has a predetermined softening temperature; superposing a facing web on the other face of said liner with a film of a thermoplastic adhesive material having a predetermined softening temperature interposed between the facing web and the liner of the corrugated fiberboard, the facing web having a degrading temperature which is lower than said softening temperatures; holding the facing web; the film of the thermoplastic adhesive material and the corrugated fiberboard together between first and second die blocks with the facing web facing said first die block; press-forming the facing web, the film of the thermoplastic adhesive material and the corrugated fiberboard together into the desired shape by said first and second die blocks with the application of heat to said thermoplastic material and said thermoplastic adhesive material from said die blocks such that the temperatures of said thermoplastic material and the thermoplastic adhesive material are maintained above their respective predetermined softening temperatures during the press-forming process; and allowing the resultant laminar structure of the facing web and the corrugated fiberboard to cool for allowing said thermoplastic material and said thermoplastic adhesive material to set, wherein a predetermined temperature to which said first die block is heated is lower than said degrading temperature of said facing web and a predetermined temperature to which said second die block is heated is higher than said respective softening temperatures of said thermoplastic material and said thermoplastic adhesive material.

The features and advantages of a method according to the present invention will be more clearly understood from the following description taken in conjunction with the accompanying drawings in which:

Fig. 1 is a schematic front elevation view showing, partially in section, an apparatus adapted to put the method according to the present invention into practice, the apparatus being shown to be in a condition ready to be put into operation;

Fig. 2 is a sectional view showing a condition in which the die blocks forming part of the apparatus illustrated in Fig. 1 are in positions pressing therebetween a corrugated fiberboard with a facing web and a film of a hot melt adhesive material superposed on one face of the corrugated fiberboard;

Fig. 3 is a cross sectional view showing part of an example of a composite board structure produced in a method according to the present invention; and

Figs. 4A to 4D are cross sectional views showing portions of various examples of corrugated fiberboards which can be used as the basic component of a composite board struc-

ture to be produced in a method according to the present invention.

Referring to Figs. 1 and 2 of the drawings, an apparatus adapted to carry out a method according to the present invention is shown comprising a down-stroke type hydraulic hot-press 10 having first and second or upper and lower die blocks 12 and 14 having complementarily convex and concave lower and upper pressing surfaces 16 and 18, respectively. Each of the die blocks 12 and 14 has opposite side wall portions each having a substantially flat, horizontal surface which forms part of each of the lower convex pressing surface 16 of the upper die block 12 and the upper concave pressing surface 18 of the lower die block 14, such a flat, horizontal surface defining the upper end of each of the pressing surfaces 16 and 18. The upper die block 12 is supported by the plunger of a hydraulic cylinder 20 which is mounted on a top cross member of a frame structure 22 so that the die block 12 is vertically movable toward and away from the lower die block 14 which is held stationary. The upper movable die block 12 and the hydraulic cylinder 20 are arranged in such a manner that a certain clearance 24 is formed between the lower convex pressing surface 16 of the die block 12 and the upper concave pressing surface 18 of the lower stationary die block 14, as indicated by phantom lines. The clearance 24 which is to be formed between the respective pressing surfaces 16 and 18 of the die blocks 12 and 14 in this fashion is so shaped and sized to conform to the desired configuration and thickness of the composite board structure to be produced from an initially flat corrugated fiberboard 26 and a facing web 28 of a non-woven fabric or a sheet of thermoplastic material such as a cellular foam of polyurethane. Thus, the respective convex and concave pressing surfaces, 16 and 18 are shaped conformingly to the desired curved configuration of the composite board structure to be produced.

The upper movable and lower stationary die blocks 12 and 14 are formed with hot-fluid circulating passageways 30 and 32, respectively. The passageways 30 and 32 are communicable with a suitable source 34 of a hot-fluid such as boiling oil or steam through valved pipes or ducts 36 and 38, respectively. The pipe 36 leading to the hot-fluid circulating passageway 30 in the upper movable die block 12 is arranged to be at least partially movable or deformable relative to the hot-fluid source 34 so as to enable the die block 12 to move relative to the hot-fluid source 34 which is held stationary. If desired, a pair of suitable web retaining assemblies 40

and 40' may be mounted on the vertical side walls of the frame structure 22 and positioned in the vicinity of the upper ends of the side wall portions, respectively, of the lower stationary die block 14 as shown.

In operation, the initially flat corrugated fiberboard 26 having a film 42 of a hot melt adhesive material superposed on the upper face of the blank 26 is placed substantially horizontally on the uppermost flat ends of the lower stationary die block 14, forming a cavity 44 between the underside of the corrugated fiberboard 26 and the upper concave pressing surface 18 of the die block 14. A facing web 28 of a non-woven fabric or a sheet of thermoplastic material such as a cellular foam of polyurethane is positioned over the film 42 of the hot melt adhesive material and is clamped along its side marginal portions extending alongside the uppermost flat ends of the upper concave pressing surface of the lower stationary die block 14 by means of the web retaining assemblies 40 and 40' on the frame structure 22 as will be seen from Fig. 2. The die blocks 12 and 14 are kept heated by the hot fluid which is circulated through the respective hot-fluid circulating passageways 30 and 32 in the die blocks 12 and 14 from the hot-fluid source 34.

When the hydraulic cylinder 20 is actuated to drive the upper movable die block 12 to move downwardly, the die block 12 is first brought into contact with the upper face of the facing web 28, which is accordingly stretched over the corrugated fiberboard and is forced against the upper face of the film 42 of the hot melt adhesive material on the corrugated fiberboard 26. This causes the initially flat corrugated fiberboard to be partially warped into the cavity 44 in the lower stationary die block 14. As the corrugated fiberboard is thus warped deeper into the cavity 44 in the die block 14, the fiberboard 26 is caused to have its side marginal portions urged inboardly between the die blocks 12 and 14. When the upper movable die block 12 reaches the previously mentioned predetermined lowermost position forming the clearance 24 between the lower convex and upper concave pressing surfaces 16 and 18 of the die blocks 12 and 14, respectively, the corrugated fiberboard is totally clamped between the pressing surfaces 16 and 18 and is deformed into a configuration conforming to the configuration of the clearance 24, as shown in Fig. 1.

When the facing web 28 and the corrugated fiberboard 26 are being thus pressed between the lower convex pressing surface 16 of the upper movable die block 12 and the upper concave pressing surface 18 of the lower stationary die block 14, the film 42 of the hot melt adhesive material between the facing web 28 and the corrugated fiberboard 26 is heated in part by the heat transferred through

the facing web 28 from the upper movable die block 12 and in part through the corrugated fiberboard from the lower stationary die block 14 and is fused between the facing web 28 and the corrugated fiberboard 26.

The corrugated fiberboard per se is made up of at least one planar liner and at least one corrugated medium formed of a paper or of a thermoplastic material which is fusible when heated. The corrugated medium of paper is bonded at the tops of its ridge portions to the liner or liners by means of a layer or layers of a hot melt adhesive material while the corrugated medium of thermoplastic material is bonded also at the tops of its ridge portions directly to the liner or liners. When the fiberboard is heated between the upper concave pressing surface 18 of the lower stationary die block 14 and the facing web 28, the layer or each of the layers of the hot melt adhesive material in the corrugated fiberboard including the corrugated medium of paper is fused throughout its area in contact with the liner or each of the liners, or the corrugated medium of thermoplastic material is fused at the tops of its ridge portions contacting the liner or liners. When the film 42 of the hot melt adhesive material between the facing web 28 and the corrugated fiberboard 26 is fused and causes the facing web 28 to stick to the outer face of the fiberboard 26, the liner or each of the liners of the corrugated fiberboard 26 is also caused to stick to the corrugated medium by means of the fused hot melt adhesive material interposed between the liner and the corrugated medium of paper or directly by the corrugated medium of thermoplastic material which is locally fused at the tops of the ridge portions of the medium. When the corrugated fiberboard 26 thus having the facing web 28 attached to one face thereof is removed from the die blocks 12 and 14 and is allowed to cool, the layer of the fused hot melt adhesive material in the fiberboard 26 or the locally fused corrugated medium of thermoplastic material in the fiberboard 26 as well as the layer 42 of the fused hot melt adhesive material between the facing web 28 and the corrugated fiberboard are allowed to set so that not only the facing web 28 is securely attached to the corrugated fiberboard but also the individual component sheet materials making up the corrugated fiberboard which has been deformed into the configuration dictated by the configurations of the respective pressing surfaces 16 and 18 of the die blocks are enabled to maintain their respective configurations.

When the corrugated fiberboard is being deformed from an initially flat configuration, unusual mechanical stresses and strains tend to be produced in those portions of the fiberboard 26 which are being warped or bent. Such mechanical stresses and strains are taken up by the heat transferred to the fiberboard

26 so that production of creases and/or fissures that would otherwise be caused by the stresses and strains can be prevented if the fiberboard 26 in its entirety is heated to a temperature which is properly controlled or which is maintained within a certain predetermined range. For this reason, it is important in carrying out the method according to the present invention to have the lower stationary die block 14 heated to a temperature higher than the temperature to which the upper movable die block 12 is heated. Where the corrugated fiberboard is of the type which has a corrugated medium of a thermoplastic material as above discussed, the temperature to which the corrugated fiberboard must be selected in consideration of not only the above described requirement for taking up the unusual stresses and strains produced in the fiberboard 26 being deformed but also the softening temperature of the thermoplastic material forming such a corrugated medium. In carrying out the method according to the present invention for the production of a composite board structure using as the basic component of the structure a corrugated fiberboard including a corrugated medium of a thermoplastic material, it is preferable that the lower stationary die block 14 be heated to a temperature within the range of from about 160°C (320°F) to about 200°C (392°F). In this instance, it is preferable to have the movable die block 12 heated to a temperature within the range of from about 100°C (212°F) to about 140°C (284°F) so that the facing web 28 is enabled to be properly softened without the risk of producing creases or destroying the embossed patterns, if any, on the outer face of the web 28.

While it has been described with reference in Figs. 1 and 2 that the fiberboard initially has a flat configuration and is deformed into a desired configuration simultaneously when the facing web 28 is being bonded to the fiberboard 26, the fiberboard may be deformed into the desired configuration prior to the step by which the facing web 28 is bonded to the fiberboard 26. As an alternative, the individual component sheet materials to form the corrugated fiberboard may be left separate from one another until the facing web 28 is to be attached to one of the component sheet materials of the fiberboard 26. In this instance, the component sheet materials to form the corrugated fiberboard are superposed on each other with a thin film of a hot melt adhesive materials interposed between the corrugated medium and the liner or each of the liners to constitute the corrugated fiberboard if the corrugated fiberboard is of the type using a corrugated medium of paper. No matter which of these processes may be chosen, the film 40 of the hot melt adhesive material may be preliminarily bonded to either the facing web 28 or the fiberboard which has been pre-

formed or which is composed of separate component sheet materials.

Fig. 3 shows the cross section of an example of a composite board structure produced in a method according to the present invention. The composite board structure herein shown uses as the basic component of the structure a double-faced corrugated fiberboard 26a consisting of two spaced parallel liners 46 and 46' and a single corrugated medium 48 which is bonded at the tops of its ridge portions on both sides of the medium to the respective inner faces of the liners 46 and 46'. The corrugated medium 48 may be made of a paper so as to be bonded to the liners 46 and 46' by means of films or layers 50 and 50' to the respective inner faces of the liners 46 and 46', respectively, as in a corrugated fiberboard 26a shown in Fig. 4A or may be made of a thermoplastic material which is directly bonded to the respective inner faces of the liners 46 and 46' as in a corrugated fiberboard 26b shown in Fig. 4B. In a composite board structure thus using a double-faced corrugated fiberboard as the basic component of the structure, the facing web 28 is bonded over its entire area to the outer face of one of the liners 46 and 46' by means of the layer 42 of a hot melt adhesive material as illustrated in Fig. 3 in which the facing web 28 is shown attached to the outer face of the liner 46'.

As an alternative to the double-faced or corrugated fiberboard 26a or 26b shown in Fig. 4A or 4B, a single-faced corrugated fiberboard consisting of a single liner 46 and a corrugated medium 48 which is formed of a paperboard and bonded to one face of the liner 46 by means of a film or layer 50 of a hot melt adhesive material as in a corrugated fiberboard 26c shown in Fig. 4C or which is formed of a thermoplastic material and is directly bonded at the tops of its ridge portions on one side of the medium to one face of the liner 46 as in a corrugated fiberboard 26d illustrated in Fig. 4D. To have the single-faced corrugated fiberboard 26c or 26d united with the facing web 28 to construct a composite board structure the facing web 28 may be attached either to the corrugated medium 48 or to the outer face of the liner 46 by the fusion of the film 42 of the hot melt adhesive material.

Besides the examples of the corrugated fiberboard herein illustrated in Figs. 4A to 4D, a corrugated fiberboard of any other type such as of the multiple type may be utilized as the basic component of a composite board structure to be produced in a method according to the present invention.

The hot melt adhesive material which is to be used for bonding the facing web 28 to the corrugated fiberboard and/or which may be used for forming the fiberboard may be polyethylene, polypropylene, polyvinyl

chloride (PVC), polyvinyl acetate, polystyrene, an ethylene-propylene copolymer, or an ethylene-vinyl acetate copolymer.

# WHAT WE CLAIM IS:—

1. A method of producing a composite board structure, comprising:

preparing a corrugated fiberboard by joining a liner to a corrugated medium such that the tops of the ridge portions defined on one side of said corrugated medium are bonded to the inner face of said liner by means of a thermoplastic material which has a predetermined softening temperature;

superposing a facing web on the other face of said liner with a film of a thermoplastic adhesive material having a predetermined softening temperature, interposed between the facing web and the liner of the corrugated fiberboard, the facing web having a degrading temperature which is lower than said softening temperature;

holding the facing web, the film of the thermoplastic adhesive material and the corrugated fiberboard together between first and second die blocks with the facing web facing said first die block;

press-forming the facing web and the corrugated fiberboard together into the desired shape by said first and second die blocks with application of heat to said thermoplastic material and said thermoplastic adhesive material from said die blocks such that the temperature of said thermoplastic material and the thermoplastic adhesive material are maintained above their respective predetermined softening temperatures during the pressforming process; and

allowing the resultant laminar structure of the facing web and the corrugated fiberboard to cool for allowing said thermoplastic material and said thermoplastic adhesive material to set,

wherein a predetermined temperature to which said first die block is heated is lower than said degrading temperature of said facing web and a predetermined temperature to which said second die block is heated is higher than said respective softening temperatures of said thermoplastic material and said thermoplastic adhesive material.

2. A method as set forth in claim 1, further comprising substantially inelastically deforming said corrugated fiberboard and said facing web each at least in part into three-dimensionally curved configurations while the corrugated fiberboard and the facing web are being pressed and heated between said first and second die blocks.

3. A method as set forth in claim 1, further comprising substantially inelastically deforming said corrugated fiberboard at least in part into a three-dimensionally curved configuration before the corrugated fiberboard is pressed

and heated together with said facing web between said first and second die blocks.

4. A method as set forth in claim 1, in which said liner and said corrugated medium of the corrugated fiberboard are superposed on one another without being united together before said corrugated fiberboard is pressed and heated together with said facing web, said corrugated fiberboard being heated together with said facing web, said corrugated fiberboard being formed from said liner and said corrugated medium simultaneously when the blank and said facing web are pressed and heated together between said first and second die blocks.

5. A method as set forth in claim 1, in which said corrugated medium is formed of said thermoplastic material and is fusion bonded at the tops of its ridge portions on one side of the medium to one face of said liner when said corrugated fiberboard is pressed and heated together with said facing web between said first and second die blocks.

6. A method as set forth in claim 5, in which said predetermined temperature to which said first die block is heated is within the range of between 160°C and 200°C.

7. A method as set forth in claim 6, in which said predetermined temperature to which said second die block is heated is within the range of between 100°C and 140°C.

8. A method as set forth in claim 5, in which said facing web is bonded by the fused thermoplastic adhesive material of said film to the other face of said liner.

9. A method as set forth in claim 5, in which said corrugated fiberboard further comprises another liner which is joined to said corrugated medium such that the tops of the ridge portions defined on the other side of side of said corrugated medium are bonded to the inner face of said another liner by means of said thermoplastic material.

10. A method as set forth in claim 1, in which said corrugated medium is constructed of paper, said medium being bonded at the tops of its ridge portions on the one side of the medium to the one face of said liner by said thermoplastic material which forms a film interposed between said liner and said corrugated medium.

11. A method as set forth in claim 10, in which said facing web is bonded to the other face of said liner by the fused thermoplastic adhesive material of said film when said corrugated fiberboard is pressed and heated together with the facing web between said first and second die blocks.

12. A method as set forth in claim 10, in which said corrugated fiberboard further comprises another liner which is joined to said corrugated medium such that the tops of the ridge portions defined on the other side of said corrugated medium are bonded to the inner

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face of said another liner by means of said reference to the accompanying drawings.  
thermoplastic material.

13. A method as described herein with

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2 SHEETS

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FIG. 1

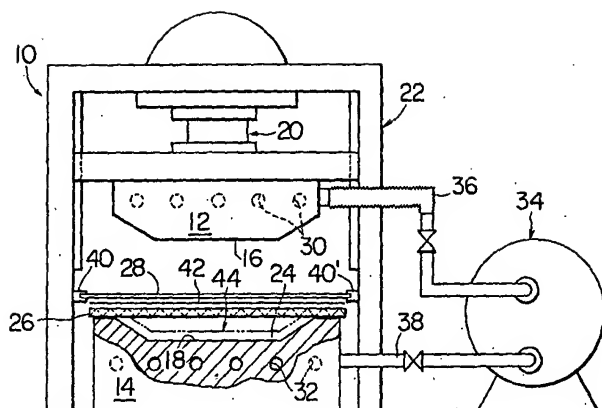
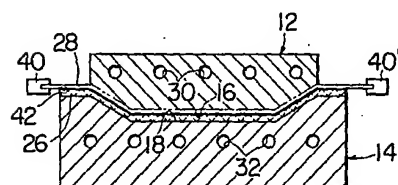


FIG. 2





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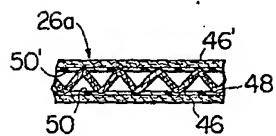
2 SHEETS

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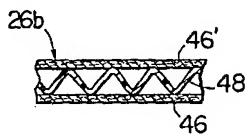
**FIG. 3**



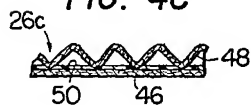
**FIG. 4A**



**FIG. 4B**



**FIG. 4C**



**FIG. 4D**

